

## International Space Station Update

*Astronauts use new robotic arm for space station assembly training*



NASA JSC Photo S99-12315 by James Blair

Multi-use Remote Manipulator Development Facility team members, from left, front (kneeling): Mike Montz (project manager), Ken Ngo, Issa Zaid, Dago Rodriguez, Ken Alder, Matthew Ha, John Tran, Duane Johnson, Dean Landry, Alan Bell, Paul Bielski, Alberto Trujillo, Toby Martin (integration manager); middle: J.B. Buentello (kneeling), John Peck (kneeling), Heather Baker (standing), Anita Kemmerling (standing), Kim Baker (standing); back: Jim Brock, Larry Merkel, Tony Doran, Richard Bussey, Doug Seiler, Frank Moore, Joe Hubbard, Garlan Moreland, Andre Sylvester (branch chief), Richard Pedersen, P.D. Lambert, Lebarian Stokes, Sam Bishop, Ed Van Maulden, Rob Bailey, Dana Snyder. Not pictured: West Womack (Lockheed integration manager), Alex Lin, Lucien Junkin, Scott Killingsworth, Kent Talbot, Anna Gutkowski, Zack Cruess.

**W**ith the completion of the massive Multi-use Remote Manipulator Development Facility in Bldg. 9, JSC has acquired an important new addition to its array of astronaut training tools.

This 15-ton, 60-foot-long "robotic arm" is a full-scale replica of the Canadian-built Space Station Remote Manipulator System, designed to operate in a gravity environment. The flight SSRMS is currently at the Kennedy Space Center in Florida being readied for launch into space aboard the space shuttle next summer.

The MRMDF will provide pre-flight training for astronauts who will eventually operate the actual SSRMS on orbit to assemble the space station. The MRMDF can simulate activities that will be conducted by the SSRMS such as removing modules from the shuttle payload bay, moving them around the station, and positioning them for final assembly.

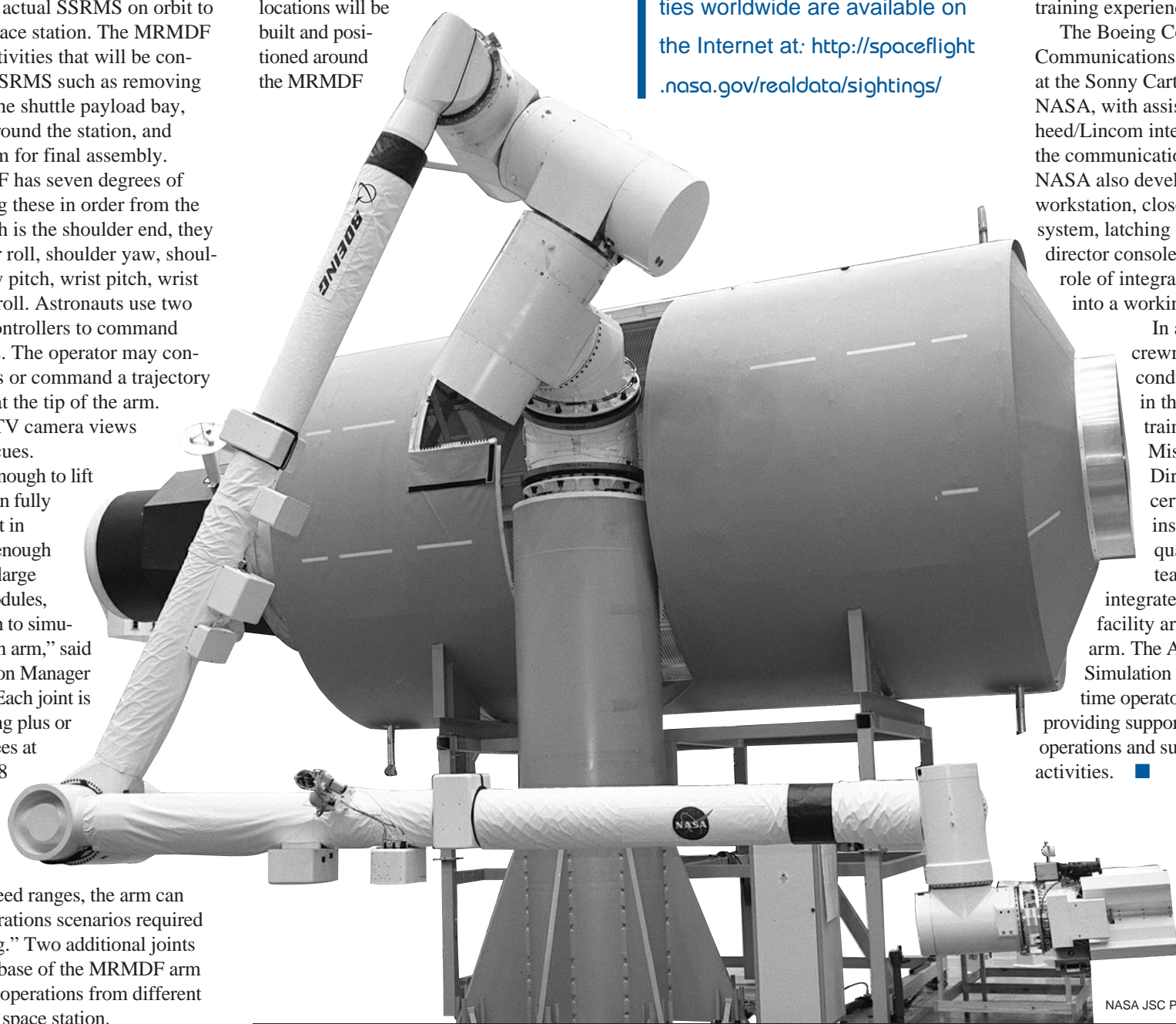
The MRMDF has seven degrees of freedom. Taking these in order from the fixed end, which is the shoulder end, they are the shoulder roll, shoulder yaw, shoulder pitch, elbow pitch, wrist pitch, wrist yaw, and wrist roll. Astronauts use two joystick-type controllers to command desired motions. The operator may control single joints or command a trajectory for the motion at the tip of the arm. Closed-circuit TV camera views provide visual cues.

"It's strong enough to lift 500 pounds when fully extended, 60 feet in length, flexible enough to reach around large space station modules, and rigid enough to simulate the Canadian arm," said NASA Integration Manager Toby Martin. "Each joint is capable of turning plus or minus 270 degrees at speeds as low .08 degrees per second and as high as 5.0 degrees per second.

Within these speed ranges, the arm can recreate the operations scenarios required for crew training." Two additional joints reconfigure the base of the MRMDF arm to simulate arm operations from different locations on the space station.

Ensuring that the MRMDF would be capable of joint operation at low speeds was one of the major challenges in designing and constructing the facility. "In space, moving the arm and payloads too fast would be dangerous," said Mike Montz, who served as the MRMDF project manager. "So, arm motion in the training facility had to smoothly simulate the low speeds normally used in space. This was a challenge with such a large mechanical device, and it took a dedicated team effort from NASA and contractor employees to make it successful."

To simulate the space station environment, mockups representing various station locations will be built and positioned around the MRMDF



NASA JSC Photo S99-12316 by James Blair

**C**ircling the Earth every 92 minutes, the International Space Station is orbiting at an altitude with a high point of 248 statute miles and a low point of 230 statute miles. Since Zarya was launched last November, the station has completed more than 5,000 revolutions of the planet. Space station viewing opportunities worldwide are available on the Internet at: <http://spaceflight.nasa.gov/realdats/sightings/>

arm. Essentially, the arm will remain stationary while the simulated space station changes around it. Mockups that are currently in use include the Node, Laboratory Module, Orbiter Payload Bay, Airlock and Spacelab Pallet.

"The MRMDF is an important training aid for International Space Station astronaut crews," said Andre Sylvester, chief, Dynamic Systems Test Branch. "It is the only dynamic hardware simulation for high-fidelity Intra-Vehicular Activity training available to the crewmember operators. It has been determined by the crewmembers that manipulation of actual hardware provides them with a useful training experience."

The Boeing Company's Space and Communications Division built the arm at the Sonny Carter Training Facility. NASA, with assistance from the Lockheed/Lincom integration team, developed the communications and control software. NASA also developed the cupola training workstation, closed-circuit television system, latching end effector and test director console. Lastly, NASA had the role of integrating all of these elements into a working training system.

In addition to the astronaut crewmembers who will be conducting flight procedures in the MRMDF during their training operations, the Mission Operations Directorate provides certified robotic training instructors who are qualified operators, and the team members who integrated the arm into the facility are certified to operate the arm. The Automation, Robotics and Simulation Division will be the full-time operator of the facility, providing support for maintenance, operations and sustaining engineering activities. ■